THE PHYSICAL EDUCATION SERIES

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APPLIED ANATOMY AND KINESIOLOGY

THE MECHANISM OF MUSCULAR MOVEMENT

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PREFACE TO THE THIRD EDITION.

IN presenting the third edition of the "Applied Anatomy and Kinesiology," I cannot but feel gratified by the kindly reception that has been accorded to it, and wish to thank those readers who have reported errors and made constructive criticisms. Such a book needs first of all to be accurate, and so I hope that any others who find mistakes or lack of clearness in the text will advise me, in the interest of all concerned.

The charts added to the third edition are some that have proved useful in my own classes. The additional cuts given in the Appendix are intended to aid students in fixing clearly in mind the exact origins and insertions of the muscles, without which the mental picture of any muscle is too vague to be of much use in indicating what it can do. The drawing of the muscles on a diagram of the skeleton furnished to the student is proving exceedingly useful in the same direction.

W. P. B.

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PREFACE TO THE FIRST EDITION.

KINESIOLOGY is the science of bodily movement. It includes a study of the principal types of muscular exercise, with inquiry as to how they are performed, how they react on the body, and their relation to the problems of bodily development, bodily efficiency, and the prevention and cure of certain defects and deformities. To make such a study it is necessary to analyze complex movements into their simplest elements, note carefully what bones, joints, and muscles are involved, what part each muscle has in the work, and under what mechanical conditions its work is done. There are two main reasons for our interest in the subject.

The first of these reasons which may be mentioned is the scientific one. All complex problems challenge our ability and stimulate a desire to master them. People are especially interested in the use of force to accomplish results, and show wonder and curiosity whenever they see a printing press, a steam thresher, a dynamo, or a locomotive in action. Interest in such machines is largely due to their complexity, which hides the manner of their action and stimulates curiosity as to how they work. The human body is a machine more complex and adaptable to a greater variety of work than any other to be found in the whole range of nature and invention. Machines have been built that are larger than the body and that are capable of greater speed, but no machine has been made nor is likely to be made that can walk, swim, climb, throw, lift, or strike, as occasion demands, although the body is considered very defective unless it can do all these things and many more. When we think of the really complex and difficult feats the body can perform, as illustrated by the performances of ball players, acrobats, jugglers, etc., it is plain that the body is in a class by itself as a marvellous piece of machinery. This is why no spectacles draw such crowds nor create such enthusiasm as exhibitions of human skill;

it is also the reason why there are no problems more fascinating to the student of science than those of Kinesiology.

The second reason for our interest in Kinesiology is practical. The work done by the machine reacts on the machine, modifying its development and the efficiency of its action. The maxim of biologists that "Function determines structure" is nowhere more true or more important than in muscular work. Although heredity has some part in it, nevertheless what we are depends largely on what we have done. The difference in physique between the athlete and the bookkeeper is in great measure the result of different kinds and degrees of activity. The reaction of the work upon the body is not only developmental but mechanical, for it influences the posture of the joints and the shape of the bones. Those who examine large numbers of men soon learn to tell almost immediately from the look of a man what his previous occupation has been. It follows that anyone who wishes to keep his own bodily machinery up to a fair grade of efficiency will do well to study Kinesiology, while those who plan to direct the bodily activities of others with a view to development and health need to have its main principles constantly in mind.

The study of Kinesiology brings us into a fascinating borderland lying between the fields of several sciences. We must first of all study something of anatomy, because we need to be very familiar with the size, structure, and location of the muscles, the exact points where they join the bones that act as levers, the nature of the joints on which they act, etc.; even those who have studied anatomy for other purposes can afford to review briefly the points of most importance here. We must note the way muscles do their work, which brings us into the field of physiology. A brief excursion into the field of mechanics is necessary to make us familiar with the problems of leverage and of the composition and resolution of forces. Finally, in studying the causes and conditions of certain bodily defects we touch upon the domain of pathology and therapeutics; and all the time we are close to the field of personal hygiene.

The real test of the mastery of this subject by the student is the ability to analyze and solve problems of Kinesiology that occur daily in the practice of the physician and the physical educator. Even if the main problems, as stated and explained here, are learned

thoroughly, they occur in actual practice in such infinite variety and with such constant change of form that no one can deal with them effectively without the exercise of some ingenuity. Many physicians and teachers are so little versed in Kinesiology that they never see many of these problems that are constantly presenting themselves, to say nothing of solving them, much to the misfortune of their patients and pupils. Many cases are so complex and difficult that they should be referred at once to specialists; a fairly efficient student of Kinesiology can determine such cases at once.

W. P. B.

EDITOR'S PREFACE.

The first experience of most medical students in the dissecting room is one of disappointment at the apparently unfavorable position in which the muscles appear to be placed for the work that they are supposed to do, and it is only after more careful study that the intricate and exquisite adjustment of position to action is discovered. Increased knowledge stimulates appreciation of this intricacy until the student of Kinesiology will cheerfully argue all night about the real action of the biceps, already overworked as an illustration, but whose action is seldom correctly stated, or on the less obtrusive intercostals the functions of which have divided scholars into two hostile camps for the last hundred years.

The understanding of accurate muscular action is most vague, even in the minds of otherwise well-trained physicians, and I have seen committees of learned doctors absolutely at a loss to explain how a frail little woman could resist with ease the united strength of four strong men or how she could apparently change her weight at will. These wonderful feats which seem out of all proportion to her visible power are but examples of muscular action diverted to deceive those who are ignorant of the subject treated in this book, and the fact that so few detect them illustrates the density of the fog that in most minds envelops the simplest problems of muscular action.

The less theatrical application of these principles is employed by the American Posture League, in designing clothing, furniture, machinery and even car seats so that the mechanical construction of the body may be respected and not deformed. Its committees are doing much by the study of the principles discussed by the author to slacken the constant and insidious strain of nerve, muscle, ligament and bone that pulls down the efficiency of both young and old.

But there is still more urgent need of knowledge on this subject at the present time.

During and after the great war, behind every battle front, in hospitals and camps, tens of thousands of crippled soldiers have been brought back to strength and usefulness, largely by the reëducation of muscular movements.

In undertaking the editorship of this physical education series, of which this is rightly the first volume, I see the possibility of doing a real service to education and medicine by helping to place physical education on the plane that its importance and dignity demand.

Both by training and inclination, Mr. Bowen is especially well adapted to write the initial volume; a practical teacher and a close student of applied anatomy for many years, his pen has not been idle, and in the following pages he has gathered the fruits of his ripened experience and mature judgment for the large audience that awaits him.

R. Tait McKenzie, M.D.,
Editor.

CONTENTS.

CHAPTER V.

Movements of the Shoulder-joint.

CHAPTER VI.

Movements of Elbow, Forearm, Wrist and Hand.

CHAPTER VII.

Movements of the Hand.

PART III.

THE LOWER LIMB.

CHAPTER VIII.

Movements of the Hip-joint.

CHAPTER IX.

MOVEMENTS OF THE KNEE-JOINT.

CHAPTER X.

MOVEMENTS OF THE FOOT.

PART IV.

THE TRUNK.

CHAPTER XI.

MOVEMENTS OF THE SPINAL COLUMN.

CHAPTER XII.

BREATHING.

CHAPTER XIII.

THE UPRIGHT POSITION.

PART V.

GENERAL KINESIOLOGY.

CHAPTER XIV.

CHAPTER XV.

CHAPTER XVI.

CHAPTER XVII.

APPLIED ANATOMY AND KINESIOLOGY.

PART I.

GENERAL PRINCIPLES.

CHAPTER I.

MUSCULAR STRUCTURE AND ACTION.

THE muscles are the immediate source of all the energy the body can use to move itself and other things. Originally derived from the sun, this energy is caught and stored by plants in latent form in the food materials they produce. These are eaten, digested, absorbed, and then built up anew into the structure of the muscles, where the energy so long imprisoned can be set free to do work. With the long series of chemical changes involved in this storage of energy, its preparation, its rebuilding into muscle tissue, and its final dissolution during muscular action we are not concerned here. The way muscles use the energy, however, when it is set free, is related to their internal structure, and something of this we must now observe.

The entire muscular system includes nearly 200 pairs of muscles, but only about 75 pairs are involved in the general posture and movement of the body, and our study will be limited to this number. The others are smaller and are concerned with such minute mechanisms as those controlling the voice, facial expression, and the act of swallowing. The muscles, like the bones, are of various sizes and shapes, every one of the 75 pairs being recognizable by its size and form. Some are in flat sheets, like the trapezius (Fig. 30) and the transversalis (Fig. 144); some are long and slender, like the sartorius (Fig. 92) and the peroneus longus (Fig. 113); some are spindle-shaped, like the biceps (Fig. 50) and the pronator teres (Fig. 70); most of them are of such irregular shape